APPENDIX A

Sampling Design

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SAMPLING DESIGN FOR SCHOOLS AND CHILDCARES

DEFINITION OF SOIL SAFETY PROGRAM SERVICE AREA

This section describes the methodology used for defining the Soil Safety Program Service Area. The Soil Safety Program service area (SSP service area) was established in a two step process. First, reevaluation of previous CUA study zone boundaries incorporating new data; second, modifying the boundary based on local health department recommendations.

The SSP service area was developed by a work group comprised of Ecology, Public Health-Seattle & King County, and Tacoma-Pierce County Health Department. The methodology is based on the methodology used to define child use study zones in the 2002 King and Pierce County child-use area (CUA) studies (Glass 2002).

Four factors relevant to the issue of defining a service area were identified:

1. A recent law (Chapter 70.140 RCW) states that the Washington State Department of Ecology (Ecology) in cooperation with DSHS, OSPI, and the local health districts shall "Identify schools and childcares that are located within the central Puget Sound smelter plume based on available information; and Conduct qualitative evaluations to determine the potential for children's exposure to area-wide soil contamination."

2. Funding for CUA sampling and BMP implementation is limited. As outlined in the TSP Project Plan, geographic areas with high levels of arsenic and/or lead in soil are a higher priority than geographic areas with moderate levels of arsenic and/or lead in the soil.

3. The footprint studies targeted relatively undisturbed forested locations; therefore, the sampling results are very likely to be an upper bound on soil contaminant concentrations at more developed and disturbed child use properties.

4. Data from the extended footprint studies has further refined the areas where area-wide contamination exists.

The CUA study zone boundary in 2002 was based on the first footprint studies in King and Pierce counties. For the SSP service area, data from all footprint studies including the extended footprint investigations was compiled into log-scaled graphs of arsenic concentration versus distance. The graphs can be used to determine the outer bounds of the TSP contamination for each wind direction. The Work Group decided to use a criterion value of 100 ppm soil arsenic - equal to the break between moderate and high concentration ranges identified by Ecology - for defining the SSP service area. All of the footprint studies targeted undisturbed areas where concentrations of area-wide contaminants are likely to be highest. Concentrations at disturbed areas such as schools and childcares are likely to be significantly

less as indicated by previous sampling results at schools and childcares. Therefore, use of a criterion value of 100 ppm soil arsenic is likely to produce a SSP service area boundary that includes all schools and childcares with high concentrations, and most with moderate concentrations.

The general methodology for defining the SSP service area boundary, based on the concentration versus distance graphs, was taken from the previous CUA study design (Glass, 2002) and includes the steps below. The data has already been partitioned into subsets by wind sectors (using the 16 sectors defined by typical wind roses), and plotted for maximum arsenic concentration versus distance for each wind sector.

1. Hand-draw the approximate bounding line for the plotted data.
2. Use the hand-drawn bounding line to estimate the intercept and slope values, and thereby establish the bounding curve equation.
3. Solve the equation for the bounding curve for each wind sector to calculate a distance to the 100 ppm soil arsenic criterion value.
4. Use the resulting distances for each wind sector to plot a child use study zone.

The initial SSP service are boundary (2006) is plotted with the old CUA study zone (2002) (Figure 2 of Design). The initial SSP service area boundary was modified based on local health department recommendations. The initial SSP service area boundary in King County nearly doubled the area of the original CUA study zone. Due to the density of childcares and schools in King County and limited resources, Public Health-Seattle & King County recommends focusing sampling efforts on the area roughly inside the original CUA study boundary with minor variations based on geographic and political boundaries. The final SSP service area boundary reflects this recommendation in King County, and uses the expanded boundary in Pierce and Thurston counties. Sampling activities in King County may eventually extend further as time and funding allow. The SSP service area is shown on Figure 3 of Design.

SAMPLING METHODOLOGY FOR SCHOOLS AND CHILDCARES

This sampling design addresses planned soil sampling of schools and childcares within the SSP service area. The sampling design includes approaches for sampling and analyzing soil, and methods for data evaluation.

SELECTING PLAY AREAS (DECISION UNITS)

Once the schools and childcares have been selected for sampling, a consistent design will be used to collect soil samples. This section discusses the concept of **Play Areas** (formerly identified as decision units) at the school or childcare.

A school or childcare property may be subdivided into multiple areas - reflecting various child activities, land uses, property histories, or other factors - at which soil is accessible by young children and exposures can occur. Only those areas where children play frequently will be selected for sampling. The data from soil sampling at these areas will be evaluated to characterize the exposure risks and assess appropriate response actions and their timing. Different parts of a child use property may therefore be treated as separate Play Areas, since the decisions on appropriate response actions may vary from one portion of the property to another based on the contaminant concentrations found.

Small childcares will often have only a single Play Area. For example, a childcare operated out of a private residence may have only a single fenced outdoor play area in the back yard of the property, perhaps 40 ft by 60 ft in size. An elementary school property tens of acres in size, on the other hand, may have a demonstration garden area, several areas with play equipment, various ball fields, and perhaps even a nature exploration area. Such an elementary school would best be classified into multiple Play Areas for sampling purposes.

Play Areas will be defined at the selected school or childcare by the field sampling teams, based on observations, discussions with property owners or operators, and the qualitative assessment questionnaire provided in Appendix C. Soil samples will be collected from all play areas within each property. The set of defined Play Areas at a school or childcare does not have to provide complete coverage of the entire property. Well-maintained grass lawns that are not used significantly by young children, for example, may not be included in any of the defined Play Areas. Some play areas may also already have a deep cover layer (e.g., 12 inches of wood chips) that minimizes contact with potentially contaminated soils, and so may not be included in the sampling. Play Areas should be at a minimum 100 ft^2 and at a maximum the size of a typical ball field (e.g., around 1 acre). To the extent practical, Play Areas should reflect fairly homogeneous activities and development histories.

SAMPLING WITHIN PLAY AREAS

The design for collecting soil samples within play areas is discussed in the following sections, including the number of boring locations, the selection of specific boring locations, the depth interval to be sampled, and the soil sample collection method.

NUMBER OF BORINGS

Samples will be collected from eight borings[1] at each Play Area. In unusual circumstances, the field sampling teams may modify that number somewhat; for example, additional samples could be required to include samples from all locations within a Play Area where soil contact was likely to occur, and subdividing the single Play Area into multiple Play Areas is not reasonable.

In choosing a number of sampling locations per Play Area, the Work Group considered the variability that can occur within areas the size of Play Areas. Information available from detailed sampling at Ruston/north Tacoma and Everett Smelter Site properties, and from previous TSP investigations, suggests that variability in soil contaminant concentrations can be substantial within sizes that may typify Play Areas. There is little to suggest that this variability is highly correlated with Play Area size. Therefore, the number of boring locations will not vary with Play Area size.

A smaller number of boring locations per Play Area would allow a larger number of schools and childcares to be sampled, within the available budgets. On the other hand, the larger the number of boring locations, the more representative the characterization of contamination within the Play Areas will be. Estimates of both the average and maximum contaminant concentrations will improve as the number of locations sampled increases. The decision to include eight boring locations per Play Area was informed by previous sampling design studies (including statistical evaluations of possible error rates as a function of the number of locations sampled, at Ruston/north Tacoma and the Everett Smelter Site). It is consistent with the sampling intensity for the completed CUA studies and the property-by-property sampling at the Everett Smelter Site. Recognizing that any number of samples per Play Area will still result in some non-zero error rates, it was the judgment of the Work Group that eight boring locations would provide reasonably accurate characterizations and allow for sampling at a significant number of schools and childcares.

BORING LOCATIONS

During the previous CUA study, boring locations were discussed in some detail, various ideas about how boring locations should be selected, and what the results of sampling should represent regarding "potential exposure risks from soil contact." The idea of an "average exposure concentration" serves to illustrate these discussions. Since exposures at CUAs are assumed to occur over an extended

[1]For this document, the term "boring" is used to denote a sampling location, regardless of the technique used to physically collect the sample. For shallow soil sampling, hand-sampling methods are likely to be used rather than equipment to advance true borings. The term "boring" has been used in previous TSP studies in this way and has also been used as a database field descriptive term.

period of time and, as a result, contact with more than a single specific location will occur, one relevant measure of exposure - particularly for chronic or cancer health risks - is the average exposure concentration over time. On close examination, the Work Group determined that different arrangements of boring locations could represent different types of average soil concentrations:

1. A random grid layout for sampling could reflect a spatial average over the entire Play Area. This would assure the best spatial representation of the Play Area as a whole. It would also reflect a simple assumption of equal probability for soil contact at any location within the Play Area.

2. Not all locations within a Play Area may be judged equally likely to result in soil contact. Child activities and behaviors may be focused at certain locations more than others - for example, areas with play equipment rather than lawn areas. Locations of bare soils, versus areas of well-maintained grass cover or wood chips, may also result in more potential exposure because they are attractive to young children and because direct soil contact is much more likely. Grid sampling could be restricted to only areas judged to have comparatively greater potential for soil exposures. This restricted spatial sampling would bias the average concentration toward those parts of a Play Area where exposure is judged most likely to occur. It includes an assumption of equal probability of soil contact in only designated parts of the Play Area. Some locations within the Play Area would not be represented at all by selected boring locations. Some reasonable estimates of areas of focused activity and most likely contact are often available from observations and short interviews at child use properties.

3. The potential for soil contact and contaminant exposure may vary in response to a number of factors: the types of child activities and their resulting intensity of soil contact; the frequency and duration of those activities by locations within the Play Area; and the presence or absence (a matter of degree) of cover materials between the child and soil. Instead of sampling with a single grid spacing to reflect equal probability soil contact over defined areas (see above), a weighted assignment of boring locations could be used to represent these factors (i.e., obtaining more samples from locations with more potential soil contact). Thus, different grid sampling densities could be used in different areas of focused activity, and some areas may not be sampled at all. If information on the factors contributing to soil contact was complete and accurate, this approach would move farthest away from simple spatial averaging toward averages reflecting actual exposures. Such information in practice is always incomplete and imprecise. Moreover, these patterns of soil contact usually vary significantly among children and over time.

The decision on how to select boring locations reflects choices about using bias and weighting factors, versus adopting the simpler equal-probability-of-sampling approach. The Work Group decided that the primary objective of evaluating exposure risks at CUAs makes it appropriate to bias samples toward locations where soil contact is more likely to occur. Information to apply a detailed weighting approach, with varying sampling intensities or estimates of varying soil contact, is considered too uncertain to be applied quantitatively. Therefore, field sampling teams will use their judgment in assigning sampling intensities to various areas of focused sampling within each decision unit.

The Work Group also decided that it would be appropriate in most instances to obtain some information in all parts of a Play Area where soil contact is possible, even if less likely.[2] As a result, a few boring locations may be assigned to areas - such as well-maintained lawns - which would not be identified as biased locations with higher probability soil contact. If no biased locations can be identified (a uniform, grassy playfield, for example), then simple spatial grid sampling will be used. Sampling to provide spatial coverage of a Play Area, even if some parts have less intense sampling, provides an opportunity to reveal highly variable conditions that could result from the usually poorly-documented history of soil disturbance from property development.

The Work Group recognized that a calculated arithmetic average using a mixed approach to sampling (biased plus spatial coverage locations) will represent neither a purely spatial average nor a purely exposure average, but something in-between. Nevertheless, this approach was chosen as best meeting the needs for CUA sampling.

The selection of boring locations will be made by the field sampling teams in the field at the time of sampling. They will identify areas of focused sampling, where soil contact is deemed most likely, through observations and discussions with owner/operators. (Initial requests for information may be made before going to the field to sample). The intensity of sampling in the selected areas of focused sampling, and in remaining areas, will be assigned using field team judgment. Overall, the selection of boring locations will reflect some degree of bias toward higher-probability contact areas wherever information to support the identification of such areas exists. The field sampling teams should document the rationales for their assignment of boring locations at each Play Area.

All boring locations will be restricted to areas of accessible soil. Thus, soil beneath buildings, paved driveways or patios, deep covers of gravel or other non-soil materials or otherwise inaccessible materials will not be sampled. Boring locations will also be restricted to locations with potentially contaminated soils; thus, imported sand in self-contained (lined) sandbox play areas, where no potential for digging to soils below the sand exists, will not be sampled.

The previous CUA studies included other exclusion criteria to preclude sampling in locations where other, non-smelter sources may significantly affect soil contaminant levels. These exclusion criteria provided setback distances from such other recognized potential sources as treated wood, leaded gasoline emissions from vehicle use, and painted surfaces. For this Soil Safety Program, the work group decided to <u>not</u> use the exclusion criteria. Defining the service area focuses sampling in areas most likely

[2]Recall that not all parts of a child use property need to be included in one of the Play Areas that will be sampled. Sampling to provide spatial coverage is in relation to a Play Area, not to the child use property as a whole.

to have smelter plume related contamination. Once at the play area, we are interested in the amount of arsenic or lead present irregardless of the source as the legislation directs Ecology to reduce exposures to arsenic and lead. Sampling will not be targeted at other sources of arsenic or lead, unless children are playing nearby. For example, a shed in the backyard that may be painted with lead based paint – sampling will not take place next to the shed just because the shed is present. Sampling next to the shed will take place if children play near the shed.

SAMPLE COLLECTION

All samples collected and analyzed at schools and childcares will represent discrete samples, collected from a single depth interval from a single boring. Soils from multiple borings will not be composited for lab analyses. Discrete samples will provide the most detailed information on soil contamination in a Play Area. They will support direct rather than indirect evaluations of whether or not criteria for maximum concentrations are exceeded (see Data Analysis and Decision Criteria section). Information on the variations in concentrations within a Play Area will also be provided by the set of discrete sample results.

Note: While a spatial pattern for soil contamination may be suggested by the discrete results, considerable caution should be exercised in making spatial interpretations. The variability in results even on a very small spatial scale (e.g., within a few feet of a given boring) can be quite large, especially where development has disturbed native soils, and the suggested spatial pattern may not be reliable. It is for this reason that decisions on appropriate response actions are typically made for a Play Area as a whole.

Sample Depths

Samples will be collected from one depth interval in each boring: 0 to 6 inches. The "zero" depth from which depth measurements will be taken is defined to be the bottom of the root mass for grass cover, just below other types of cover (e.g., wood chips), or just below the duff layer if one exists. Clean sand will be treated the same as other cover materials, since previous sampling confirmed that clean sand materials (without admixed soil) have low arsenic and lead concentrations. Sample collection will therefore start just below any shallow cover layer (e.g., less than 4 inches of sand)

One depth interval will provide information to characterize the potential for children's exposure to surface soil from playing or shallow digging. Previous CUA investigations sampled from two depth intervals (0 to 2 inches and 2 to 6 inches). Two depth intervals allowed samplers to evaluate the vertical distribution of arsenic and lead and determine the types of behavior (i.e, digging or playing on surface soil) that may cause a child to come in contact with different soil concentrations. However, depth profile

results from the footprint studies show a strong 1:1 correlation between arsenic concentrations from 0 to 2 inches and from 2 to 6 inches. This suggests that collecting samples from a single depth would yield similar results. Collecting soil samples from 0 to 6-inch soil depth is consistent with the sampling depth recommended in the CUA sampling guidance (Ecology 2005) and is also consistent with the focus on characterizing possible exposure risks under current conditions - that is, not considering site redevelopment, utility construction projects, or other less frequent but possible activities that would disturb soils to a greater depth. Sampling one depth will allow sampling at more schools and childcares within the available budget. Ecology has developed and applied its moderate and high concentration ranges for the TSP Site for conditions in the top 6 inches of soil at CUAs

The proposed sampling design for the Play Areas addresses the specific objectives of the Soil Safety Program. It is not intended to provide complete characterization of soil contamination at a Play Area. Sampling at 0 to 6 inches may not include the maximum contaminant concentrations at a Play Area; about 30 percent of the non-beach Play Areas sampled in the Vashon-Maury Island CUAs study had maximum concentrations below 6 inches (see Public Health - Seattle & King County and Glass 2001). Soil disturbance at developed sites can result in much more complex contaminant depth profiles than in undisturbed soil. Sampling to only 6 inches will not fully define those contaminant depth profiles. In fact, the absence of any elevated concentrations within the top 6 inches is no assurance that contamination does not occur below 6 inches (as may result from the importation of a foot of clean fill soil during property development, for example). Therefore, the results from sampling of the top 6 inches will not be used to determine compliance with MTCA cleanup levels.

Collection Method

Sample collection will start just below any shallow cover layer (e.g., less than 4 inches of sand). The entire 6 inch depth of soil will be collected, placed in a stainless steel bowl, and thoroughly homogenized. An aliquot of soil will then be placed in a clean sampling jar, filled to the top of the jar. The sampled will be properly labeled and kept cool during transportation to the laboratory.

SAMPLE ANALYSIS

All CUA samples will be analyzed for total (unspeciated) arsenic and lead. No collected samples will be archived without analysis.

Information available from previous studies was reviewed to confirm that other smelter-related contaminants did not need to be analyzed for these studies. Based on the maximum soil concentrations found in previous studies of Tacoma Smelter impacts and direct soil contact exposures and risks as

calculated under MTCA[3], other elements known to be related to smelter emissions appear unlikely to pose significant risks, individually, at school and childcare play areas. This confirms earlier screening-level reviews, but with an expanded set of results on additional elements including more recent studies. Moreover, the other smelter-related contaminants are expected to show a high degree of correlation with arsenic and lead results. Arsenic and lead were judged to remain sufficient indicator contaminants for making decisions at school and childcare play areas.

Consistent with earlier TSP studies and with MTCA requirements, sample preparation will include homogenizing and sieving the samples prior to analysis. All analyses will be performed on subsamples from materials < 2mm in size.[4] Total arsenic and lead results will also be reported on a dry weight basis. Therefore, percent moisture (percent solids) will also be determined for each sample to support lab calculations of dry weight concentrations. Soil samples should be archived by the lab after analysis pending authorization for disposal by the contracting agency.

Analytical methods should be selected with detection limits low enough to reasonably limit the frequency of not-detected results, which will affect the calculation of average concentrations by depth within Play Areas to some degree. Most arsenic and lead results are expected to be above 5 ppm; essentially all are expected to be above 1 ppm. Evaluations of soil contamination at CUAs are not expected to be significantly affected by not-detected results as long as the detection limits are approximately 5 ppm or less. To this end, EPA Method 6020 will be used.

DATA ANALYSIS

The results from sample analyses will be evaluated using two numerical measures: average and maximum concentrations.

1. The maximum arsenic and lead concentrations in any single sample within a Play Area will be identified and recorded.

[3]The more complex risk evaluations associated with plant uptake and garden vegetable consumption were not included in this brief review, which was undertaken as only a screening-level evaluation.

[4]For the Soil Safety Program, the size fraction specified in the MTCA regulations - <2mm - will be analyzed.

2. The arithmetic average concentrations[5] for arsenic and lead, using results from all boring locations in the play area, will be calculated and recorded. The detection limit will be used (conservatively) for any not-detected results in making these calculations.

These data evaluation measures will support both comparative and absolute (numerical) assessments of the magnitude of soil contamination at the play areas at the schools and childcares, and the potential risks of exposures for young children. Response actions will follow as described in sections 2.2.8 through 2.2.10 of the main text of this report.

Ecology has established a set of numerical concentration ranges for the TSP Site to define levels of contamination that are below standards, moderate, or high (see Table 2-2 in the main text of this report). Ecology or the Health Departments will compare average results to the moderate and high concentration ranges to determine a below standards, moderate, or high contaminant level designation. Maximum sample results will also be compared to the moderate and high concentration ranges. If any sample is greater than 2 times the lower value for the contaminant level category, the Play Area will be assigned to that contaminant level category. BMPs will be recommended for play areas in the moderate or high categories. The BMPs recommended may reflect the level of contamination.

REFERENCES

Ecology. 2005. CUA Arsenic and Lead Soil Sampling Guidance. Washington State Department of Ecology. Ecology publication #03-09-037 (revised 5-05).

Glass, Gregory L. 2002b. Sampling Design for Tacoma Smelter Plume Site; Soil Sampling and Analysis at Child Use Areas in King County and Pierce County, Washington. November.)

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[5]The Work Group decided not to use a calculated upper confidence limit on the average concentration as a formal data evaluation endpoint. Such upper confidence limits may be calculated, and the results made available on request, but they will not be directly used by the agencies in making decisions based on school and childcare sampling. The Work Group noted that the calculation of upper confidence limits is often itself uncertain for technical reasons, particularly for small data sets with variable results. Moreover, the purposes for the school and childcare sampling are distinct from final cleanup decisions under MTCA, and a different data evaluation approach was judged appropriate.